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Comparative performance of UASB and anaerobic hybrid reactors for the treatment of complex phenolic wastewater

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HIGHLIGHTS

- Performance of AHR and UASB reactor was compared for the removal of phenolics.
- Fast start-up and granulation of biomass was noted in AHR.
- Lowering HRT led to decline in phenolics removal in AHR(99–77%) and UASB(95–68%).
- AHR could withstand higher shock load compared to UASB reactor.
- 12,159 MJ d^{-1} more energy can be generated using AHR.

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ABSTRACT

The performance of an upflow anaerobic sludge blanket (UASB) reactor and an anaerobic hybrid reactor (AHR) was investigated for the treatment of simulated coal wastewater containing toxic phenolics at different hydraulic retention times (0.75–0.33 d). Fast start-up and granulation of biomass could be achieved in an AHR (45 d) than UASB (58 d) reactor. Reduction of HRT from 1.5 to 0.33 d resulted in a decline in phenolics removal efficiency from 99% to 77% in AHR and 95% to 68% in UASB reactor respectively. AHR could withstand 2.5 times the selected phenolics loading compared to UASB reactor that could not withstand even 1.2 times the selected phenolics loading. Residence time distribution (RTD) study revealed a plug flow regime in the AHR and completely mixed regime in UASB reactor respectively. Energy economics of the reactors revealed that 12,159 MJ d^{-1} more energy can be generated using AHR than UASB reactor.

1. Introduction

Coal plays an important role in meeting the global energy demand. Coal fired power plants supply 41% of the global energy demand through coal combustion. Coal conversion processes (coal gasification and coal liquefaction) are predicted to continue in most of the developing world, with coal set to fuel 44% of electricity (IEA, 2010). Wastewaters from coal gasification contain 60–80% of phenolic compounds (including phenol, methyl phenols and C2-phenols) along with aromatic nitrogen and sulfur containing compounds and aliphatic acids (Singer et al., 1978). These compounds increase the mortality of fishes at low concentrations (5–25 mg L^{-1}) and impart objectionable tastes to drinking water (Hill and Robinson, 1975). Due to the potential hazard of these compounds, many substituted phenols, including chloro/nitro and cresols have been listed as priority pollutants by the U.S. Environmental Protection Agency (EPA) (Keith and Telliard, 1979). Hence, elimination of these compounds becomes a necessity to preserve environmental quality.

Different treatment techniques (solvent extraction, steam stripping and activated sludge treatment) have been employed to remove organic contaminants from coal wastewaters (Luthy et al., 1983). However, several problems and drawbacks associated with these processes did not insure their techno-economic feasibility. Anaerobic treatment of coal wastewaters was carried out initially employing anaerobic activated carbon filters that resulted in a high COD removal efficiency (80–95%) at organic loading rates ranging from 1–9 kg COD m^{-3} d^{-1} (Nakhla et al., 1990). Further developments resulted in two research studies that reported the continuous anaerobic treatment of mixed phenolic compounds without activated carbon (Fang et al., 1996; Tawfiki et al., 2000). Successful treatment of coal conversion effluents requires careful selection of treatment process that insures the simultaneous degradation of

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